

FINAL REPORT

South Carolina State Wildlife Grant SC-T-F15AF00728
South Carolina Department of Natural Resources
January 1, 2016 – December 31, 2016

Project Title: Harvesting the high-hanging fruit: Using citizen-science to guide state-wide management of diamondback terrapins.

Objective 1: Development of a terrapin website and centralized terrapin sightings data base reporting.

Accomplishments: A comprehensive terrapin website launched in mid-April received 5,361 unique page visits through December. Fifty-four percent of page visits occurred during October through December (Figure 1), concurrent with outreach to generate interest among crabbers to evaluate an improved bycatch reduction device (BRD) designed by the SCDNR and purchased by the USFWS Charleston office for such evaluation (Appendix A). All website statistics were lost for September due to a glitch; thus, the activity reported above is a conservative estimate of interest in the terrapin website.

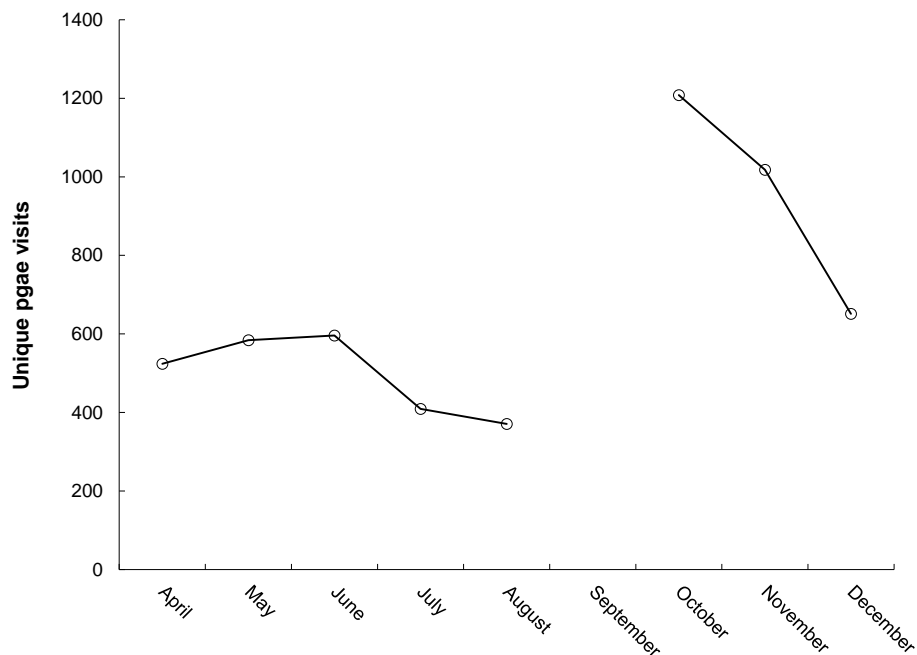


Figure 1. Greatest visitation to the diamondback terrapin website launched in April occurred in October and November, concurrent with outreach to enlist crabber participation in a BRD evaluation study.

Forty-two percent of all page visits were collectively associated with the “Research” pages, which were visited with similarity across research themes with the exception of increased visitation rates for the fisheries interactions and natural predators pages (Figure 2); interest in these two pages was comparable to the research staff and species identification pages. Thirty-eight percent of all page visits were associated with the “Resources” page where eight grant reports and one scientific presentation for SCDNR terrapin activities since 2006 were collectively downloaded 2,068 times. The homepage was visited 1,286 times representing 24% of all page visits, the second highest overall single page visit rate. The least amount of interest was associated with the research themes home page (0 visits), followed by an overview of conservation efforts (302 page visits, 6% of all page visits).

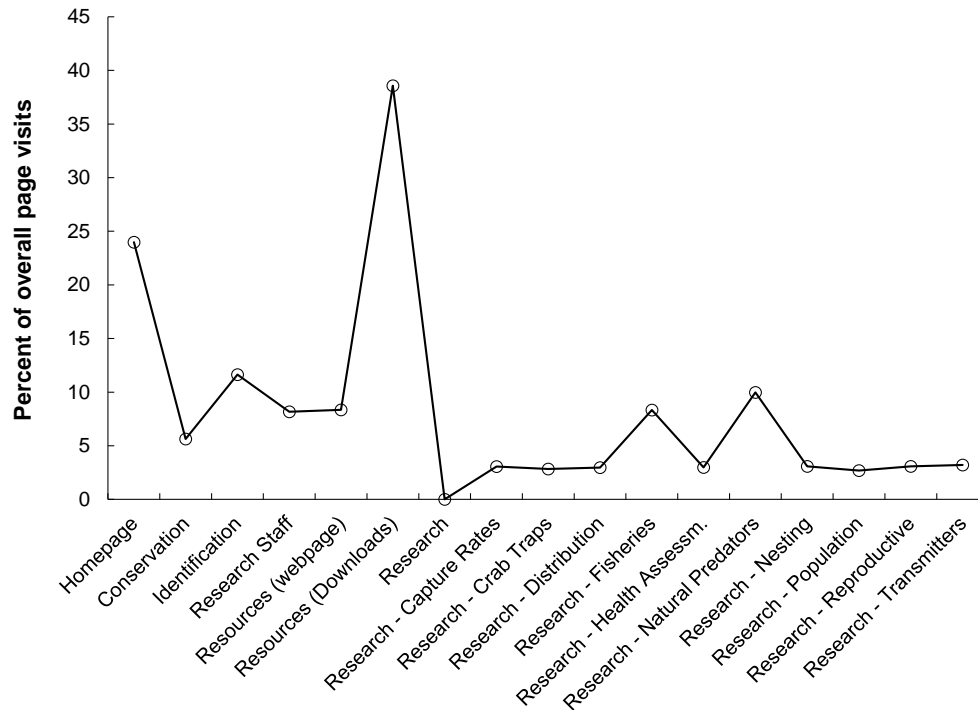


Figure 2. The greatest degree of visitation to the terrapin website was associated with downloading (2,068 times) eight grant reports and one scientific presentation for terrapin activities since 2006.

Among the top three documents accessed, the long-term catch rate trend for diamondback terrapins since 1995 received the most overall page visits ($n=548$), but was the third most frequently accessed document in any given month. Conversely, a 2009 report on terrapin bycatch reduction device (BRD) studies was the mostly frequently accessed document in any given month, but received the third most overall page visits ($n=274$). The 2013–2015 Final Report on terrapin acoustic telemetry and BRD refinement efforts was the third most frequently accessed document in any given month, but received the second most overall page visits ($n=308$). With the exception of the 2014 Annual Report on terrapin acoustic telemetry and BRD refinement that received the fourth most overall page visits ($n=213$) but was the second most frequently accessed document in any given month, the ranking of visit frequency to all other pages was highly aligned ($P = 0.005$, $r = -0.97$) with respective page visits ($n=113$ to 174).

A total of 137 terrapin sightings were reported between 30 March and 21 November, with 81% of total sightings ($n=111$) reported between April and June. Among six sighting categories, observations of terrapins on land was the most common response (37%), with 42 of 51 ‘on land’ sightings associated with adult-sized terrapins, followed by indications of terrapin nesting (28 sightings, 20%). Sightings of terrapins in the water in natural habitats accounted for 31% (42 sightings) of total sightings, with two-thirds ($n=28$) of these sightings also identified as adult-sized terrapins. Only 12 (9%) terrapin sightings were associated with fisheries-interactions, half of which were associated with incidental capture on hook and line (most commonly when shrimp was used as bait); only two reports of terrapins captured in traps were received, one of which was an illegal mesh trap set likely lost after Hurricane Matthew. Observations of nest emergence (3 sightings) and hatchlings (one on land, one in a swimming pool) were the least frequently reported sighting categories. Excluding the few fisheries interactions, seasonal occurrence of sightings within categories was highly correlated ($P < 0.01$, $r = 0.84$ to 0.99) with the seasonal distribution of overall sightings independent of category (Figure 3).

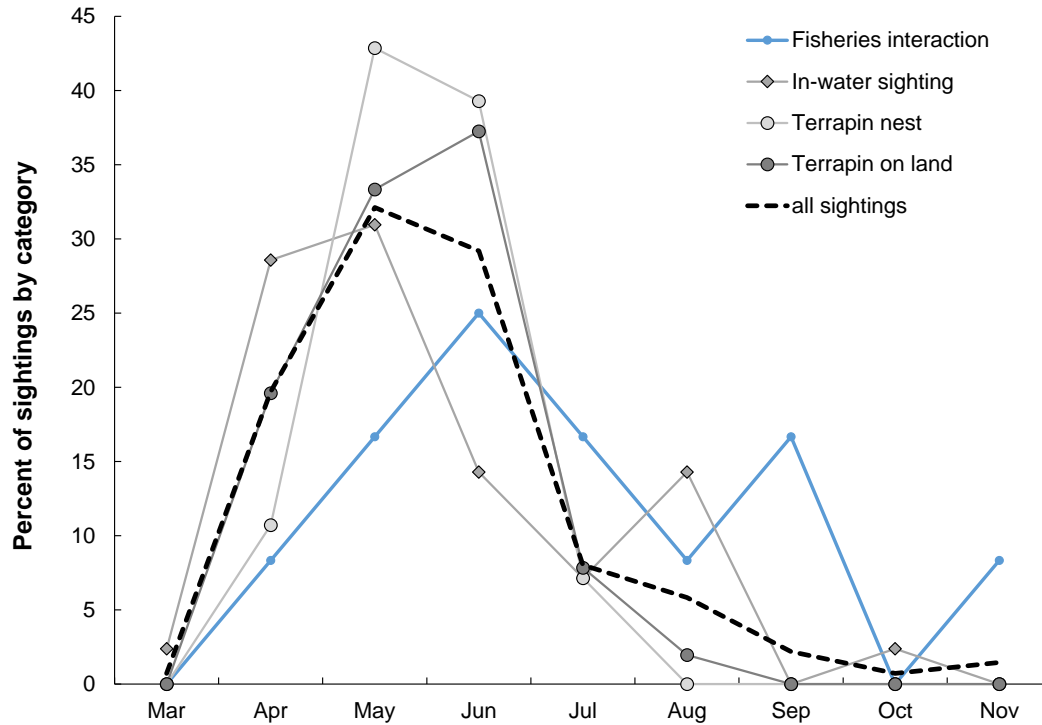


Figure 3. Seasonal disparity in the reporting of three terrapin sighting categories that collectively comprised 88% of total sightings ($n=137$) was not observed; however, a one-month lag was noted between peak in-water sightings and peak nest and terrapin-on-land sightings.

Latitude and longitude was provided (or later determined) for all but 10 (7%) terrapin sightings, all but three of which were located between 32.18°N (Hilton Head Island) and 32.89°N (Bull Island); however, three terrapin sightings were also received from 33.45°N to 33.60°N (Pawley's Island to Myrtle Beach). Categorical terrapin sightings were received with similar frequency across the reporting area (Table 1), with the exception of increased reports of nesting near Charleston, SC associated with a single reporter.

Seventy-eight percent ($n=107$) of terrapin sightings were associated with a single terrapin, with groups of six or more terrapins only reported for 12 (9%) sighting events (and no group size for four sightings). Terrapin sex was not indicated ($n=13$) or determined ($n=61$) for 54% of citizen-scientist reports, followed by identification of terrapins as female 42% ($n=57$) of the time.

Table 1. Citizen-scientist reporting of terrapin sightings occurred over a broad range of latitudes in coastal South Carolina (mean, min, and max listed), predominantly in Beaufort and Charleston Counties, with little indication of spatial variability in reporting category type across this geographic area.

Category	Mean	SD	Min	Max	N reports
Fisheries interaction	32.68	0.20	32.18	32.88	11
In-water sighting	32.71	0.26	32.21	33.58	38
Terrapin nest	32.76	0.08	32.38	32.77	27
Terrapin on land	32.63	0.24	32.23	33.60	47

Significant deviations: None.

Objective 2: Outreach to encourage citizen-scientist reporting across media types.

Accomplishments: On 14 April, a SCDNR News Release¹ was distributed to media across the state to announce the launch of the new terrapin website and online reporting form², which was also featured prominently on the website homepage. Five days later, the Post and Courier ran a story encouraging public reporting of diamondback terrapins³. Regrettably, we did not aggressively pursue media outreach throughout the remainder of the year focused solely on encouraging reporting; however, additional SCDNR news released (print and social media) soliciting public participation in other aspects of SCDNR terrapin research did indirectly draw increased attention to terrapin reporting. Similarly, the Project Investigator delivered an evening presentation to the Coastal Master Naturalist Group in Charleston in August which included a synopsis of citizen-scientist findings, also consistent with proposed outreach methods. In spring 2017, we plan to again promote further reporting (and follow-up) by the public via media release to coincide with springtime emergence and heaviest likelihood of public encounters.

Significant deviations: None, other than not conducting extensive outreach.

Objective 3: Citizen-scientist follow-up.

Accomplishments: A total of 78 citizen-scientists provided their name and minimal contact information for all but 9 of 137 (7%) terrapin reports received during 2016. A personalized email acknowledgement and thanks for providing each report was promptly provided to 74 of the citizen-scientists; the remaining four citizen-scientists received a phone call given that no email address was provided. Eighty-five percent ($n=66$) of the citizen-scientists provided only a single terrapin report, but 11 citizen-scientists provided between 2 and 5 terrapin reports and one citizen-scientist provided 32 terrapin reports. Latitude and longitude was provided for seven of nine reports for which contact name and information were omitted, with at least five spatial groupings identified; thus, it is more likely that these observations reflect single reporting events by as many individuals rather than representing multiple reports from a few individuals that simply didn't want to be identified. In addition to receiving initial thanks, citizen-scientists were notified in advance of the August presentation mentioned in Objective 2 in the event that they were able to attend, and also received a follow-up synopsis of the findings. The citizen-scientist who ultimately provided 32 terrapin reports also volunteered with SCDNR in support of Objective 5.

Significant deviations: None, other than not conducting frequent site visits to follow-up on reports due to a low frequency of dead/moribund terrapins and the ability to use Google Earth to resolve discrepancies.

Objective 4. Develop a network for treating injured terrapins and disposal of dead/moribund terrapins.

Accomplishments: Only two diamondback terrapins were reported as "alive, but injured", both of which were encountered in the water; the first terrapin was picked up by SCDNR personnel at Demetre Park on James Island for evaluation, care for lethargy, and eventual release, while the second was taken directly to the South Carolina Aquarium Sea Turtle Hospital by the citizen-scientist. Fifteen reports of dead terrapins were received, all but one of which was associated with a single terrapin per report. Ten of the dead terrapin reports originated from on land between 13 April and 11 June, while three were spotted

¹ http://www.dnr.sc.gov/news/2016/apr/apr14_terrapin.html

² <https://www.surveymonkey.com/r/SCDNRTerrapin>

³ http://www.postandcourier.com/archives/public-help-sought-in-marsh-turtle-study/article_fb63c402-61d3-53d6-9e63-37d7645f8010.html

floating in the water between 4 May and 31 August and two were confirmed fisheries interactions with a crab trap in the Ashley River (20 August) and an illegal mesh trap on Seabrook Island (14 November). Significant deviations: Due to the low frequency of reporting and thus perceived demand, we did not develop a network of responders as proposed, and instead referred concerned citizens to an existing registry of authorized reptile rehabilitators in SC: <http://www.dnr.sc.gov/wildlife/rehab/reptiles.html>

Objective 5. Continued population studies in the Ashley River.

Accomplishments: A total of 265 individual diamondback terrapins were captured in the trammel net survey between March and November (but excluding October due to Hurricane Matthew), five of which were captured twice during this sampling timeframe. Monthly processing of trammel net-captured terrapins ranged from eight (November) to 76 (May), captured at two (November) to 13 (May) different net sets in the Ashley River on each sampling day.

Male diamondback terrapins ($n=181$) were captured 2.1 times more often than females ($n=87$), and was not statistically different from 2015 ($\chi^2_1 = 0.274$, $P = 0.601$), and only 1% ($n=5$ in 2015, $n=2$ in 2016) of diamondback terrapins captured by the trammel net survey could not be confidently sexed. Although Broyles (2010) also reported male-biased captures in the Ashley River trammel net surveys in 2008–09, a significant difference was detected ($\chi^2_1 = 5.892$, $P = 0.015$) between the two observation periods such that slightly more males were captured in 2015–16 (69% of sexed terrapins) than in 2008–09 (63%).

Twenty-seven (10%) of these terrapins were previously captured in the trammel net survey between 2013 and 2015, 10 (4%) were previously captured in the trammel net survey between 2008 and 2009, and 3 (1%) were previously captured in crab trap studies to improve terrapin BRDs during 2015 and 2016; for contemporary population estimates, these previously tagged terrapins were treated as “new, unmarked” terrapins in their respective year of recapture. Similarly, within-season recaptures were disregarded for population estimates; only 6 terrapins captured in 2015 were recaptured in 2015 (1.6%) and only 5 terrapins captured in 2016 were recaptured in 2016 (2.0%). For comparison, 27 (6.3%) of terrapins captured in 2008 were recaptured in 2008, and tag issues precluded accurate estimation of within-season recapture rates in 2009 (Broyles 2010).

Formal analysis of survival rate and population estimate in Program MARK is pending consultation with E. Broyles to determine the best way to compare the two survey periods. However, Chi-square analysis of aggregate input structure revealed no significant difference ($\chi^2_2 = 5.199$, $P = 0.074$) in this data format for the two-year data sets in 2008–09 vs. 2015–16 (Table 2). Furthermore, the 95% confidence interval around mean population size reported by Broyles (2010) was 38% for 2008 data only and 36% for the combined 2008–09 population estimate; thus, it is unlikely that a significant difference would be detected in population estimates between the two temporally disparate tag-recapture efforts.

Table 2. Significant differences were not detected in the aggregate 2-year data input structures during 2008–09 (Broyles 2010) vs. 2015–16; thus, the terrapin population in the Ashley River has likely remained relatively stable for nearly the past decade.

<u>Description</u>	<u>MARK code</u>	<u>2008-09</u>	<u>2015-16</u>
Tagged in year 1, recaptured in year 2	11	26	15
Tagged in year 1, not recaptured in year 2	10	402	364
Tagged in year 2	01	343	249

Outreach to promote the demographic and abundance focus of Objective 5 was published in the Post and Courier on 16 March⁴, and batch processing of most terrapins at Northbridge Park provided additional opportunities for public outreach (Figure 4).



Figure 4. Batch processing of diamondback terrapins at Northbridge Park following capture in monthly trammel net surveys of the Ashley River increased operational efficiency for Objective 5 and provided additional opportunities for public outreach and engagement of citizen-scientists and volunteers.

Significant deviations: None, other than not sampling in October 2016 due to Hurricane Matthew.

Literature Cited:

Broyles, E. 2010. Diamondback terrapins (*Malaclemys terrapin*) of Charleston, South Carolina: Population estimate, sex ratios, and distribution. Unpublished thesis, College of Charleston, 62p.

Estimated Federal Cost: \$30,419 (award amount and spent, 1 January 2016 to 31 December 2016)

Recommendations: Close the grant

Acknowledgements: We thank the following SCDNR personnel for their assistance with website development (M. Polkowsky) as well as insight and outreach for the development and promotion of the citizen-scientist reporting form (E. Weeks, L. Sutley) in Objective 1. We also thank the 78+ citizen-scientists who reported terrapin sightings as well as E. Weeks (SCDNR), B. Peterson (Post and Courier) and G. Ware (WBTW News 13) for media coverage of SCDNR terrapin activities for Objectives 2 & 3. For Objective 4, special thanks are extended to A. Segars, W. Dillman, and E. Weeks (SCDNR) as well as K. Thorvalson and S. Boylan at the South Carolina Aquarium for coordination of rehabilitation efforts for diamondback terrapins, which fortunately were not numerous in 2016. Fifteen volunteers contributed 150 support hours for Objective 5, and we thank (in descending order of hours contributed) T. Cannon, D. Aren, C. Bayles, M. Cawley, C. Boyd, M. Bado, K. Gold, A. Carpenter, E. Shaw, E. Schultz, A. Bonka, K. Shelton, R. Dominguez, A.M. Thompson, and S. Dearhart. We are also truly grateful to J. Koches and J. Ayers (both USFWS) for their commitment to securing extramural funding for BRD distribution efforts outlined in Appendix A.

⁴ http://www.postandcourier.com/archives/the-mysterious-diamondback-dnr-studies-turtle-that-might-be-key/article_50666879-5700-5c39-8372-8278f319da1a.html

Appendix A. Continued refinement of an effective bycatch reduction device (BRD) for crab traps.

A total of 159 crab trap sets (78 control, 81 BRD) totaling 775.1 trap-hours (369.1 control, 406 BRD) were conducted on 13 sampling dates between 18 April and 4 August (Table 3) to evaluate the terrapin exclusion and legal-crab retention capabilities of a BRD design modified from the style tested in 2015. The primary physical modification associated with the 2016 design was a rounded top and bottom surface which increased the vertical clearance at the horizontal center of the BRD by 1.3 cm (0.5 in.) relative to the design tested in 2015 (Figure 5). The impetus of this design change was to accommodate deep-bodied crabs which, similar to diamondback terrapins, are 1.9 times as wide as tall when they enter crab traps (i.e., carapace length divided by carapace height). Additionally, placement of the BRD was moved as far forward in the crab trap funnel, to facilitate funnel tapering and terminal line projections that were more in line with non-BRD (i.e. control) traps.⁵

Table 3. A total of 159 crab trap sets totaling 775.1 soak hours were conducted in 2016 to evaluate a modified BRD design, with particular emphasis on retention of large, legal-sized blue crabs. An asterisk (*) indicates one overnight soak of two control and three BRD traps as a result of inclement weather that precluded the retrieval of these traps prior to the safe return of personnel to Fort Johnson. No terrapins were captured in BRD traps during the overnight soak; however, three were captured in the two control traps during the overnight soak, two of which were dead on arrival and a third died a day later.

Control						BRD				
Day	N traps	Trap-hrs	N terp	N crabs	N legal crabs	N traps	Trap-hrs	N terp	N crabs	N legal crabs
18-Apr-16	6	27.2	7	28	20	6	27.2	2	11	10
22-Apr-16	7	38.2	6	20	15	6	34.4	4	18	9
26-Apr-16	6	32.2	2	12	7	6	32.2	0	10	9
27-Apr-16	7	29.9	3	6	3	6	25.6	1	8	3
03-May-16	6	16.1	3	14	15	6	15.9	0	21	10
04-May-16*	8	67.2	7	14	5	9	90.3	0	22	18
17-May-16	6	13.2	0	3	2	6	13.3	0	3	2
18-May-16	6	19.0	0	13	9	6	19.1	0	10	4
14-Jun-16	4	22.6	0	28	5	6	34.2	0	43	2
15-Jun-16	4	18.6	0	18	4	6	27.9	0	36	10
12-Jul-16	6	28.8	0	55	5	6	30.7	0	53	11
13-Jul-16	6	31.2	0	12	6	6	31.2	0	13	3
04-Aug-16	6	25.1	0	47	15	6	24.2	0	62	17

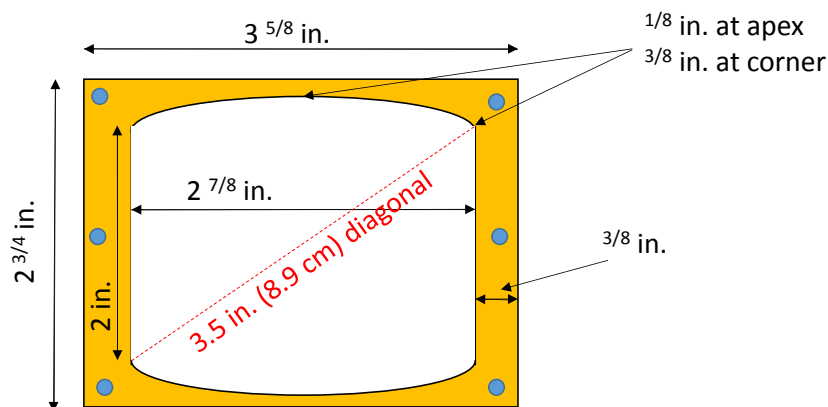


Figure 5. The 2016 BRD design represents the smallest BRD aperture ever tested and was specifically designed to accommodate large, deep-bodied crabs while simultaneously excluding terrapins.

⁵ <https://www.youtube.com/watch?v=VdE267ooZ8>

A total of 35 diamondback terrapins were captured in crab traps in 2016, 80% of which ($n=28$) were captured in control traps compared to only seven terrapin captures in BRD traps. Trap-level terrapin catch per unit effort levels were non-normally distributed and low (i.e. median \pm inter-quartile range, IQR = 0.0 ± 0.0 for both trap types); however, control traps were associated with significantly greater ($H_1 = 7.85$, $P = 0.005$) terrapin catch rates than BRD traps.

Legal-sized (i.e. carapace width ≥ 12.7 cm, 5 in.) blue crabs comprised 38% ($n=219$) of 580 blue crabs captured. In contrast to terrapin catch rates, legal blue crab catch per unit effort was not significantly different ($H_1 = 0.34$, $P = 0.562$) between control ($n=111$ crabs) and BRD ($n=108$ crabs) traps.

Males ($n=165$) comprised 76% of legal-sized blue crabs, and sex was not indicated for one legal-sized blue crab captured in a BRD trap. A significant difference was detected ($\chi^2_1 = 8.055$, $P = 0.005$) in the ratio of males to females between trap types, with males comprising 84% ($n=93$) of legal-sized blue crabs captured in control traps compared to just 67% ($n=72$) of legal-sized blue crabs in BRD traps. Similarly, despite identical minimum (12.7 cm, 5 in.) and maximum (17.8 cm, 7 in.) carapace width measurements for legal-sized blue crabs captured in control and BRD traps, a significant difference was detected ($H_1 = 10.97$, $P = 0.001$) between trap types, with slightly greater crab sizes associated with control traps (median \pm IQR = 14.4 ± 1.5 cm) compared to BRD traps (13.8 ± 1.3 cm; Figure 6).

Based on these results, the Charleston office of the US Fish and Wildlife Service purchased 1,200 BRDs in September for distribution to recreational and commercial crabbers for further evaluation. Target distribution was set at 50 recreational and 50 commercial crab traps in each of three areas: Beaufort, Colleton, and Jasper Counties; Charleston County; and Georgetown and Horry Counties. Distribution of BRDs for 115 (77% of target) commercial crab traps was achieved through November, but only 48 recreational traps' worth of BRD supplies (plus three display sets) were distributed in 2016. Hurricane Matthew disrupted BRD distribution in both crabbing sectors, but distribution to recreational crabbers also suffered from missing the prime (i.e. summer) crab fishing season. Limited input on BRD perception was received in fall/winter 2016, and results were mixed; we plan to complete the target distribution of BRDs and gauge perception of crabbers in both sectors as time permits in 2017.

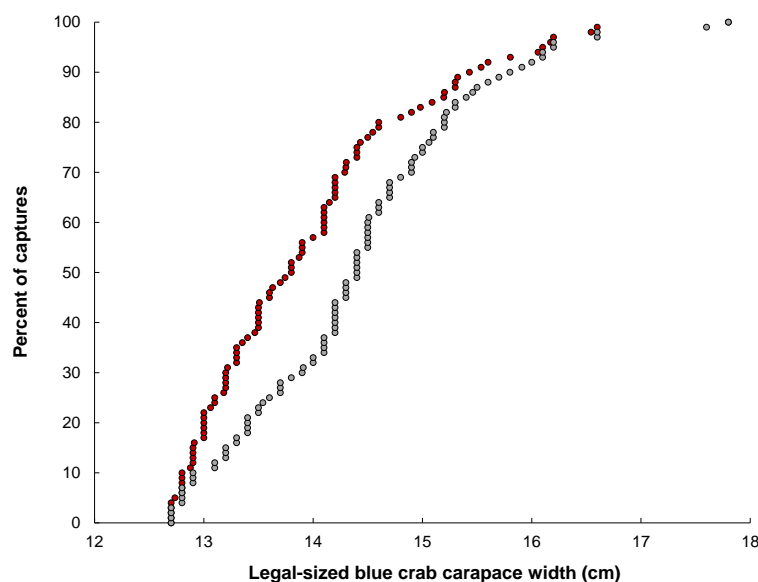


Figure 6. Similar minimum and maximum legal-sized blue crabs were captured in control and BRD traps in 2016; however, percentile distributions were shifted towards slightly larger blue crabs in control (gray circles) vs. BRD (red circles) traps.